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Community stress, demoralization, and body mass index: evidence for social signal transduction

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Abstract

Quantification of the relationship between community-level chronic stress from neighborhood conditions and individual morale has rarely been reported. In this work, pregnant women were recruited at the prenatal clinics of Harlem Hospital and Columbia Presbyterian Medical Center in the USA, and given an initial questionnaire that included all 27 questions of the Dohrenwend demoralization instrument, as well as questions about household economics and health. An index of chronic community stress (ICCS) was compiled for each of the health areas of the study zone by standardizing and weighting each stressor significantly associated with low birthweight rate and summing the standardized, weighted values. Health areas were divided into ICCS quintiles.

The graph of the quintile weighted averages of the index vs. the quintile averages of the demoralization score was an asymmetric inverted ‘U’ shape that fitted well to a stochastic resonance signal transduction model (adjusted $R^2 = 0.73$). On average, the women in the worst three quintiles were much heavier than those of the two best quintiles. Women reporting household economic deprivations were significantly more demoralized than the others. Median health area rents were strongly negatively associated with the ICCS.

The worst average demoralization score occurred in the middle quintile, a state of coping with both poor community conditions and an economically strained household. Rents bridge community conditions and household economics.

Keywords: USA; Chronic community stress; Demoralization; Body mass index; Social signal transduction; Household economic deprivation

Introduction

Length and quality of life may depend on community socioeconomic structure and neighborhood conditions (e.g. McCord & Freeman, 1990). Numerous papers have appeared recently which document relationships between the health of populations or of groups of individuals and the conditions in their neighborhoods (e.g. O’Campo, Xue, Wang, & O’Brien Caughey, 1997; Geronimus, Bound, & Waidmann, 1999; Shumow, Vandell, & Posner, 1998). Likewise, analyses of the geographic patterns of such public health problems as low-weight births, asthma, and diabetes have shown that these problems are concentrated in neighborhoods with particular socioeconomic conditions (e.g. Nyirenda & Seckl, 1998; Liteonjua, Carey, Weiss, & Gold, 1999).

The Center for Children’s Environmental Health at the Joseph Mailman School of Public Health (Columbia University) examines the possible three-way relationship within a birth cohort between the independent variables of (1) environmental chemical exposures of the mothers and babies and (2) socioeconomic conditions of the health areas and (3) dependent variables of health outcomes (developmental deficits, asthma, and carcinogen biomarkers). Because many health outcomes have been linked to the uterine environment and to the mother’s morale and stress (e.g. Phillips, 1998; Svanes,

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Omenaas, Heuch, Irgens, & Gulsvik, 1998; Collins et al., 1998), we nested the individuals in their health areas by examining relationships between the mother's demoralization, her pre-pregnancy body mass index, household economics, and health area socioeconomic conditions. Health areas were designated by the New York City Department of Health decades ago as aggregates of Census Tracts with populations of about 20,000 each.

Methods

Recruitment of the mothers

Women attending the pre-natal clinics of Columbia-Presbyterian Medical Center and Harlem Hospital were invited to participate in the program by female research workers, many of whom were bi-lingual (English and Spanish). Target populations were Dominican (either immigrant or American born) and African–American (American-born). The women had to have lived in the study zone for at least a year and be over 18 years of age and drug-free (see Fig. 1 for the primary study zone). The recruits' informed consents were ethically obtained, and the protocol of the entire program was approved by the Columbia-Presbyterian Medical Center's Independent Review Board.

Prenatal questionnaire

Each recruit was administered a detailed questionnaire before the birth of the baby. The questionnaire included section on demographics, household conditions and economics, employment, present health and health history, and the Dohrenwend demoralization probe (all 27 questions) (Gallagher, Marbach, Raphael, Handte, & Dohrenwend, 1995).

Socioeconomic data

The source of all health area level socioeconomic and health outcome data was Infoshare, a database and geographic information system program developed by Leonard Rodberg, director of Urban Studies at Queens College. The version used by the Center contained Health Department health outcome annual data through 1996 and demographic and socioeconomic data from the 1980 and 1990 Censuses such as total population; population by age, race, and sex; median household income; total employment and employment by economic sector; and housing overcrowding. Infoshare also includes annual socioeconomic data collected by the municipal government such as number of people with public assistance.

Chronic community stress index

One potential source of health disparity is chronic community level stress, stresses that do not pose a threat to life or limb but grind the residents economically, socially, or politically. An index of total chronic community stress was developed as follows: Incidence of selected socioeconomic and social-indicator health outcome factors were calculated for 1994–1996 by summing the case numbers for 3 years and dividing by the area 1990 population. Because low-weight birth is well documented in the literature as associated with maternal stress (e.g. Texeira, Fisk, & Glover, 1999), health area incidence of low-weight birth (1994–1996 number of births below 2500 g/10,000 live births) was regressed against health area incidence of each chronic stressor. Those stressors significantly associated with low-weight birth incidence with an R^2 at or above 0.2 were included in the combined index. Thus, we included only stressors imposing a population level stress of potential importance. See Table 1 for the stressors.

Each stressor incidence of each health area was standardized by dividing it by the median incidence of the 27 health areas of the Upper Manhattan study zone. Each standardized incidence was weighted by multiplying by the R^2 of its association with low-weight birth incidence. For each health area, the sum of all the standardized weighted incidences became the ICCS. To check the validity of low-weight birth incidence as an indicator of stress, we also created an ICCS based on diabetes mortality incidence because type II diabetes (the vastly dominate type) has been correlated with community stress in the literature (Rajaram & Vinson, 1998). Regression of the two indices of chronic stress yielded an R^2 of 0.99: Our low birthweight-based index appears valid.

Data ordination and analysis

All data manipulations and analyses were performed with the statistical analysis program Statgraphics Plus. The 27 separate demoralization item scores of each mother were summed to form a score of overall demoralization. The health areas were assigned to quintiles according to their ICCSs. The distributions of total individual demoralization score values within the quintiles were, with one exception, skewed normal. Average and median total scores were calculated for each quintile and plotted against the quintile weighted average ICCS of the health areas that actually had mothers living in them. Weighting was by number of mothers in the health areas. The ICCS quintiles of health areas were grouped with six health areas in the best and worst quintiles and five in each of the three middle quintiles.

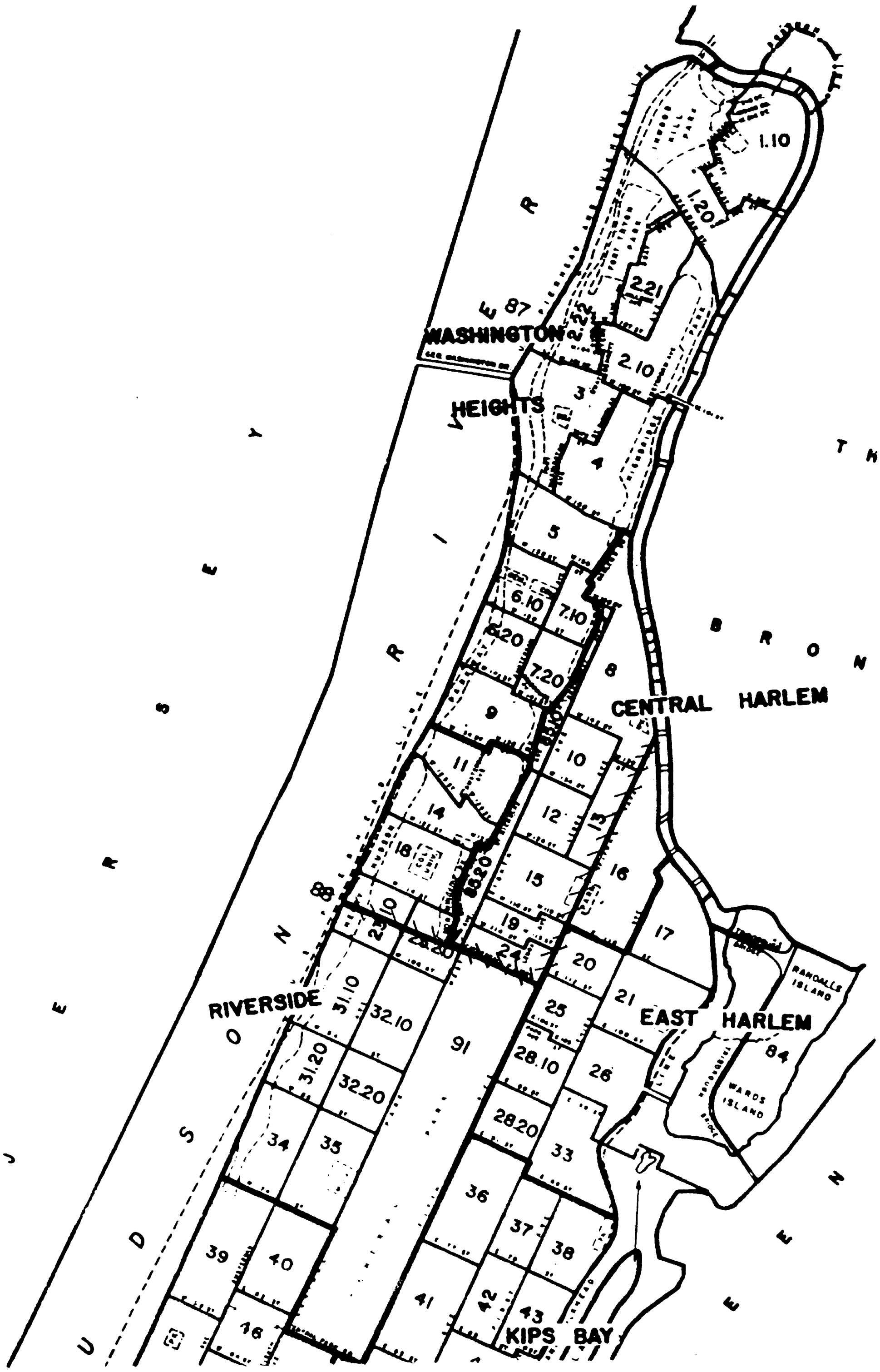

Fig. 1. Map of the primary study zone (Upper Manhattan). The heavy lines with the light cross-lines mark the boundaries of the zone (Fifth Avenue on the East and 110 Street on the South). The numbers within the health areas are their numerical designations assigned by the New York City Department of Health and used in this study to identify the areas.

Table 1
Unweighted standardized chronic stressers and community chronic stress index

Health area	Drug*	Cirrhosis*	Unemploy**	% Welfare	% Poverty	Overcrowd#	1/Median income	Pop change	%Foreign	CCSI
1.1	0.519	0.839	0.646	0.743	0.849	1.59	0.77	−0.607	1.725	53.5
1.2	0.197	0.883	0.831	1	0.887	0.83	0.87	−0.297	1.87	57.0
2.1	0.625	1	1.041	1.01	1.064	0.73	1	−1.372	2.41	−3.4
2.21	0.129	0.646	0.96	0.992	0.968	1.58	0.85	−1.472	2.367	−37.2
2.22	0.148	0.195	0.689	0.378	0.453	0.53	0.61	0.595	1.11	77.7
3	0.102	1.006	0.804	0.809	0.884	0.54	0.74	−1.114	2.013	−27.6
4	0.300	0.567	1.173	1.114	1.158	1.21	1.04	−1.274	2.437	−1.4
5	0.564	1.012	1.044	1.048	1	0.51	0.97	−0.765	2.152	41.8
6.1	1.029	0.687	1.017	0.978	0.981	0.48	0.89	0.39	1.44	165.0
6.2	1.055	0.231	0.862	0.995	0.92	0.59	0.99	0.328	1.841	131.9
7.1	1.320	0.889	0.847	0.942	0.977	0.88	0.99	0.648	0.823	242.9
7.2	1.253	2.227	0.716	0.84	1.055	1	1.02	1.095	0.828	297.6
8	1.286	1.095	1.109	1.212	1.146	1.17	1.12	2.484	0.297	433.8
9	0.143	0.571	1.106	1.006	1.185	1	1.01	−1.106	1.97	18.1
10	1.430	1.377	1.559	1.302	1.412	1.35	2	2.476	0.389	514.9
11	0.222	1.665	1.008	1.415	1.389	1.42	1.47	2.145	1	367.1
12	2.235	0.291	1.07	1.381	1.241	1.28	1.41	2.991	0.278	556.5
13	2.129	4.866	1.07	1.108	0.942	1.34	1.09	3.756	0.306	628.0
14	0.626	1.228	0.812	0.652	0.846	1.08	0.78	1.893	0.721	279.7
15	2.461	1.586	1.108	1.19	1.248	0.81	1.35	2.864	0.712	511.3
18	0.085	0.414	0.392	0.424	0.392	0.17	0.66	−3.198	1.351	−195.4
19	2.263	3.942	1.103	1.313	1.637	1.23	2.04	3.94	0.434	700.6
23.1	1.201	0.325	0.571	0.195	0.408	0.62	0.56	1	0.939	156.6
23.2	0.378	2.477	0.827	0.836	0.952	0.8	0.76	1.577	1.262	247.4
24	1.560	2.458	1.119	1.135	1.328	1.47	1.54	1.581	0.48	442.4
85.1	1.000	0.706	0.841	1.187	1.402	0.94	1.49	4.069	0.53	525.7
85.2	1.132	1.941	1	0.976	1.17	1.22	1.19	2.867	0.734	434.7
weighting factor	50.09	21.36	26.02	40.81	37.99	19.63	50	65.36	−57.86	

*deaths per 100,000.
**number unemployed/population 17–64 years old, #(standardized %extremely overcrowded housing units-standardized %foreign)/median. CCSI = community chronic stress index.

Body mass index (BMI) was calculated in the standard manner by converting the height and *pre-pregnancy* weight of each recruit into kilograms and meters and applying the standard formula: weight/height∗height. The standard cutoffs were also used: BMI's over 25 were considered overweight and those over 30, obese. Average and median quintile BMI's were plotted against the weighted average quintile ICCS.

The questionnaire included five questions on household deprivation: experience of food insecurity, experience of housing insecurity, cutoff of utilities due to nonpayment, lack of needed clothing, and inability to pay for needed medical care/medicine. Demoralization score and BMI were separately regressed at the individual level against both individual household deprivations such as experience of food insecurity and against total number of household deprivations. Two household deprivation scores were developed for each quintile.

The first (DEPSCORE) was calculated as follows: (percent of women with one deprivation) + (2*percent of women with 2 deprivations) + (3*percent with 3) + (4*percent with 4) + (5*percent with 5).

The second (DEPSCORE2) omitted the percent with one deprivation. Each deprivation score indicates both incidence and intensity of household economic shortfalls within the quintiles. DEPSCORE2 omits the single instances of shortfall, in case some were mere flukes, and measures only multiple deprivations.

The four following factors were, round-robin fashion, plotted against each other: weighted average quintile ICCS, quintile household deprivation scores, quintile average demoralization score, and quintile average BMI.

Modeling demoralization and chronic stress

Signal transduction is a very general pattern seen in phenomena as diverse as neural response to stimulus (e.g. McClintock & Luchinsky, 1999), physiological response to arousal (e.g. Wilken, Smith, Tola, & Mann, 2000; Wilson et al., 2000) and in dose-response to hormonal mimics (Bigsby et al., 1999). Recently signal transduction has come to be modeled as a 'stochastic resonance' in which a signal too weak to trigger some strong threshold response is augmented by an additive noise. If the noise is too weak, no triggering occurs. If the noise is too strong, the signal is entirely washed out by the noise. Thus, the signal-to-noise ratio (SNR) of the applied signal and the much larger threshold response—effectively an amplification of the weak signal—will undergo a rise to a peak with applied noise, and then a subsequent decline as the noise overcomes the signal, according to theory, hence the characterization as a 'resonance'.

The general form for the SNR of a simple stochastic resonance, as a function of the noise amplitude x, is typically given, after some fairly arduous calculation, by the expression (Gammaitoni, Hanggi, Jung, & Marchesoni, 1998, Eq. (4.51); Braiman, Linder, & Ditto, 1995; Kadtke & Bulsara, 1997; Heneghan et al., 1996; McClintock & Luchinsky, 1999),

$$\mathrm{SNR}(x) \approx \frac{1}{x^2}[1 + \alpha \exp(1/(2x))]^{-1}. \quad (1)$$

α is a scaling parameter related to the properties of the weak applied signal.

In order to model the relation between demoralization and chronic stress we used the nonlinear regression procedure of the Statgraphics statistical package to, simultaneously, linearly rescale the chronic stress index and choose the α which best fits the demoralization data. In essence we 'argue by abduction', to use Hodgson's terminology (Hodgson, 1993), that a stochastic resonance SNR functional form will provide a good fit to 'social' as well as neural or chemical signal transduction.

Results

Demoralization and chronic stress

The summed demoralization scores ranged from one to 89. The 225 scores were skewed-normally distributed with an average of 34. The best health area with respect to ICCS had an index of −195; the worst health area, 701 (Table 1).

Four of the five sets of demoralization scores were skewed-normally distributed, and one, the middle quintile, multimodally. Thus, use of the average or median to represent the central value for these quintiles is reasonable. Fig. 2, the plot of the average summed demoralization scores of the quintiles against the weighted average chronic stress index, shows an inverted, asymmetric 'U' shape. Mann–Whitney non-parametric comparison of average rank of the summed demoralization scores of the middle with the bottom quintile and of the top with the bottom quintile yielded a statistically significant difference ($P = 0.02$) for the former and no difference for the latter ($P = 0.25$). A two-tailed t-test also showed a difference between the demoralization scores of the middle and bottom quintiles ($P = 0.01$). The asymmetry of the inverted 'U' resulted in no statistical difference between the top and middle quintiles. However, from the differences detected, the shape of this curve appears to be real and not a result of chance. The basic descriptive statistics such as mean, median, variance, and upper and lower quartiles also indicate differences between these quintiles (Table 2).

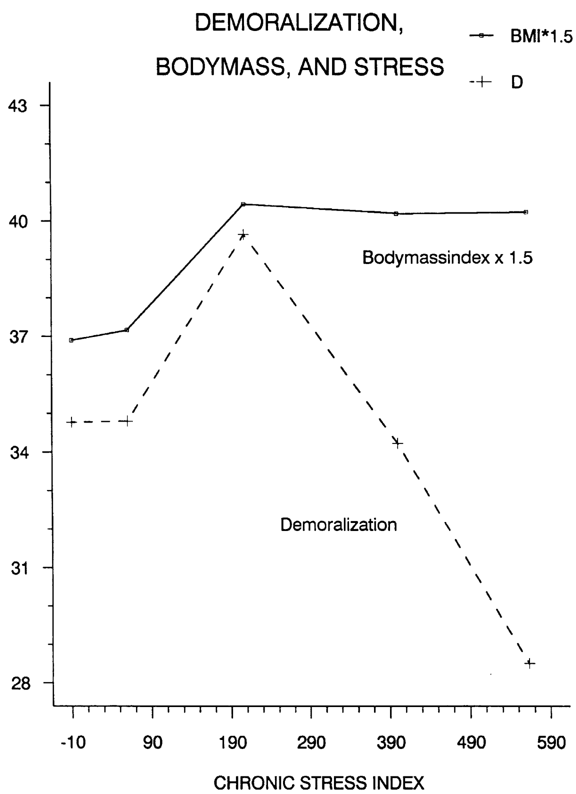

Fig. 2. Average Demoralization Scores and Average BMIs of the Chronic Community Stress Quintiles vs the Quintile Average Chronic Stress Indices. Note the inverted 'U' shape with peak in the middle for the average demoralization scores. Note the step function of the average BMIs with the high plateau of quintiles 3–5.

Because the two worst chronic stress quintiles are composed of health areas with very high proportions of African–American population, the potential difference in demoralization scores between Dominican and African–American recruits had to be explored. Five health areas were home to both Dominican and African–American recruits. T-test, Mann–Whitney

Table 2
Descriptive statistics of demoralization scores and BMIs by quintile

Demoralization scores					
Quintile	1	2	3	4	5
Average	34.78	34.80	39.65	34.23	28.51
Median	31	33	42	31	26
Geometric mean	29.86	31.09	32.32	30.33	25.59
Standard deviation	16.90	16.00	19.72	16.06	13.42
Minimum	1	7	2	6	8
Maximum	80	89	81	77	69
Lower quartile	21.5	23	25	25.5	18
Upper quartile	46	42	55	43.5	35
Body mass indices					
Quintile	1	2	3	4	5
Average	24.60	24.78	26.96	26.80	26.82
Median	23.46	22.86	25.42	25.75	25.66
Geometric mean	24.02	24.06	26.74	26.03	26.01
Standard deviation	5.90	6.48	3.57	6.59	6.86
Minimum	15.69	17.01	20.97	16.00	17.73
Maximum	55.03	45.59	33.01	45.31	42.09
Lower quartile	20.71	19.53	24.27	22.01	21.28
Upper quartile	27.49	28.42	30.62	30.68	32.88

nonparametric test, and Kolmogorov–Smirnov nonparametric test showed no statistically significant difference between the demoralization scores of the Dominican and African–American women living in these five health areas. No significant difference was found between the demoralization scores of native-born and immigrant recruits living in the same nine health areas.

In most large cities of the USA, housing consumes a large percent of the household income, larger than the recommended 25%. Regression of the health area ICCS against the 1990 median rent reveals a close negative relationship with an R^2 of around 0.7. The rents were, thus, partly determined by the community conditions. The two worst quintiles had the lowest weighted average median rents, and the residents of the two best quintiles paid over 100 a month more than those of the two worst quintiles in 1990.

Signal transduction modeling

Fig. 3 shows the result of the nonlinear regression fitting of the relation between quintile demoralization and ICCS to the stochastic resonance SNR function. Some 73% of the variance *as adjusted for the degrees of freedom* is accounted for by this model. The F-ratio (472.79) is many, many times that of the $P = 0.05$ significance level (about 19) for our degrees of freedom. The asymmetric stochastic resonance SNR relation is a very good fit indeed for our data.

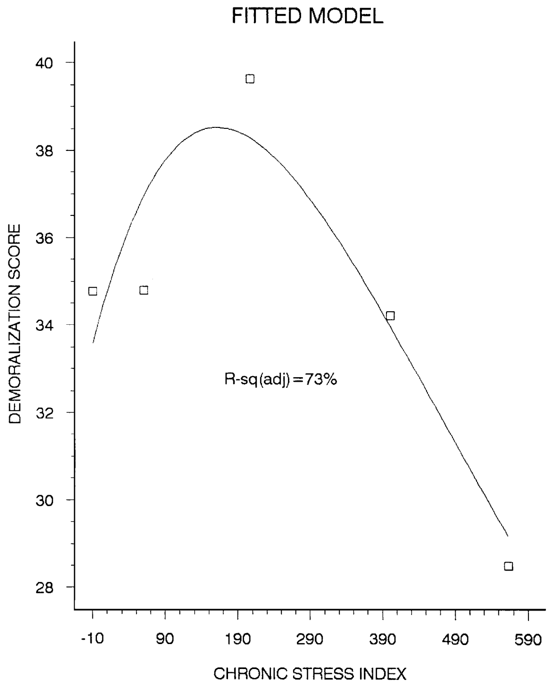

Fig. 3. Fit of the stochastic resonance signal-to-noise ratio/signal transduction model to the quintile average demoralization scores and quintile weighted average community chronic stress indices, based on 225 recruits. The data are fit by nonlinear regression to a formula of the form $\mathrm{SNR}(x) = \dfrac{1/x^2}{1 + \alpha \exp(1/2x)}$.

Body mass index

The BMI was skewed normally distributed for the over 200 women with complete height and weight data with an average of 25.68, a minimum of 15 and a maximum of 55. The distributions for each quintile, however, were not normally distributed and necessitated use of nonparametric tests for comparison. Fig. 2 displays both the quintile average demoralization scores and the quintile average BMI plotted against the weighted quintile average ICCS. The BMI appears to show a step function at the middle quintile. The BMIs of the middle quintile are significantly different from those of the best quintile in both the Mann–Whitney test ($P = 0.009$) and the Kolmogorov–Smirnov test ($P = 0.005$). Table 2 displays the basic descriptive statistics of the BMI's of the quintiles.

There was no statistically significant difference in the BMI's of Dominican and African–American women living in the same health areas. Indeed, both Dominican and African–American women live in the health areas of the middle quintile.

Household deprivation

The majority of recruits reported none of the five household deprivations (126 out of the 225). The others reported numbers of deprivations as follows:

One deprivation	49 recruits
Two deprivations	24 recruits
Three	16 recruits
Four	9 recruits
Five	1 recruit

At the individual level, the number of household deprivations was significantly associated with total demoralization score ($P < 0.00001$) but with an R^2 of only 0.15. This was the only individual level association with an R^2 above 0.1. The number of household deprivations of the individual recruits was negatively associated with the ICCS of the health areas ($P = 0.0075$) but the R^2 was very small (0.032). Number of household deprivations had no association with BMI ($R^2 = 0$).

For quintile deprivation scores, see Table 3. The household deprivation scores of the two worst quintiles with respect to ICCS are much better than those of the two best quintiles. Thus, household conditions contrast with community conditions.

Household economics also depends on the number of people sharing the resources and contributing to the resources. The numbers in the individual economic household ranged from 1 to 13. At quintile level, the average number of people per economic household was strongly negatively associated with the two deprivation scores: DEPSCORE ($P = 0.002$, $R^2 = 0.97$) and DEPSCORE2 ($P = 0.033$, $R^2 = 0.824$). At the quintile level, BMI showed a positive trend with average number of people in the economic household: $P = 0.17$, $R^2 = 0.52$.

In examining the five different forms of deprivation, strong associations were found between all but one and demoralization score. The one not associated with significantly higher demoralization scores (t-test) was utility cutoff. Food insecurity and housing insecurity were the two strongest associations:

Deprivation	Average demoralization score	
	With the deprivation	without
Food insecurity	47.7	31.5
Housing insecurity	46.0	31.2

Table 3 displays by quintile the percent of recruits reporting food insecurity, housing insecurity, average economic household size, average demoralization score, and average BMI. Note that the second best quintile shows a decidedly smaller average household size and by far the highest proportion of recruits with housing insecurity.

Table 3
Summary of data for the chronic community stress quintiles

Quintile	Weighted ave. chronic stress index	DEPSCORE	DEPSCORE2	Wted. Ave. Median rent 1990 ($)	% With food insecurity	% With housing insecurity	Ave. people/ household	Ave. demoral total	Ave. BMI
1	−9.3	93.4	77.6	438.4	22.37	23.68	2.99	34.77	24.60
2	60.8	117.4	89.1	425.2	15.22	28.26	2.70	34.80	24.78
3	208.1	85.0	65.0	376.8	20.00	20.00	3.00	39.65	26.96
4	400.9	49.9	36.3	344.7	11.36	9.09	3.25	34.23	26.80
5	563.4	56.5	20.6	314.8	5.13	10.26	3.21	28.51	26.82

Discussion

The asymmetric inverted 'U' curve

It is not reasonable to interpret the curves formed by plotting stressor quintile averages against the quintile average demoralization scores at their face values. As stress increases, women do not get better morale. The inverted 'U' shape is reminiscent of the dose/response curves of hormonally active pollutants (e.g. Andersen et al., 1999) that act by either mimicking or antagonizing naturally occurring hormones. For a detailed explanation of the inverted 'U' curve of endocrine disrupter dose/response, see Bigsby et al. (1999). We have two possible explanations for the inverted U shape which are not mutually exclusive.

Explanation 1: Like endocrine disrupting pollutants, the combined and individual chronic community stressors may act as a signal-boosting 'noise'. Above a certain level of chronic stress, the mothers or their social networks stopped responding actively to community conditions and, overwhelmed by the 'noise', withdrew from community involvement.

Explanation 2: Community conditions and rent may establish two stable systems for this population of recruits: good conditions and high rents with household economic insecurities vs. bad conditions and low rents with household economic adequacy and options.

We found a contrast between community and household conditions. The women in the two worst quintiles for community stress reported the least household deprivation. They had economic resources and more human resources, i.e. more people in their households.

One factor that spans the community and household scales is rent. The health area 1990 median rent was strongly negatively associated with the health area chronic community stress index. Rents, thus, largely are determined by community conditions. Rents heavily influence household budgets, especially within a poor, clinic-using population.

The New York City Department of Housing, Preservation, and Development reported that median contract rents increased citywide 5.9% annually between 1993 and 1996 (DHPD, 1999). The median gross rent increased 4.4% annually from \$562 to \$640. Residents paid 30% of their incomes for gross rent, as a citywide average. However, Latin Americans paid more than the average: Puerto Ricans, 34.6% and non-Puerto Rican Latinos, 32.1%.

The efficacious community shares and imposes values (Sampson, Raudenbush, & Earls, 1997). If the neighborhood community cannot impose its values and bad conditions result, the women can withdraw into their own homes and the homes of their own social network (family and close friends). This also represents a stable, psychosocially acceptable configuration. If community conditions are unstable, not so bad as to drive the decent people out of civic life, but out of control, the people who need a nice neighborhood and to exercise good citizenship experience great distress. The analogy is a cliff. The people on top of the cliff are in a stable, safe situation. The people at the bottom of the cliff are in a stable, safe situation. But the people in the air between the top and bottom are distressed and frightened.

We mathematically model this latter process in Appendix A, using the recent results of Wallace and Fullilove (1999) and Wallace (2002).

Thus, results of this analysis suggest that the Upper Manhattan study zone is a single, integral system which may be inherently unstable, and may fragment under the impetus of sufficient perturbation: Upper Manhattan truly seems to be where the South Bronx was in the early 1970s (Wallace & Wallace, 1998, 2000).

The systematic nature of these relations transcends the different 'ethnic' components of the Upper Manhattan study zone. We conclude that the dynamics of the system are driven by relatively simple indices of deprivation and community stress rather than by inherent qualities of the US social construct of 'race', although allocation and availability of the resources and services which determine community stress are, under the US system of Apartheid, largely determined at the area level by the perceived 'race' of the inhabitants (e.g. Massey & Denton, 1993).

The bodymass index

Besides producing a strong pattern for demoralization scores, the quintile weighted average ICCS produced a strong pattern for average BMI. Epidemiological papers in recent literature on human overweight and stress often report levels of markers of hypothalamus/pituitary/adrenal (HPA)axis activity (e.g. Fried, Ricci, Russell, & Laferrere, 2000). Furthermore, experiments on animal models show an unambiguous relationship between adipocyte and HPA functions that 'confirm the inhibitory effect of leptin on the HPA axis response to various stress stimuli' (Giovambattista, Chisari, Gaillard, & Spinedi, 2000). Indeed, in sheep, one type of leptin receptor has been localized in the somatostatin-containing neurons of the hypothalamus (Iqbal, Pompolo, Murakami, & Clarke, 2000). Leptin is the so-called 'fat hormone' produced by adipocytes. Thus, both human epidemiological and animal physiological data raise the possibility that the good demoralization scores in the two worst quintiles may be partially paid for with the elevated BMIs. The women in the worst three quintiles have average BMIs above 25, the standard cutoff for overweight.

'Race' and culture may be raised as a possible cause of the differences between the quintiles with respect to the two health outcomes. The lack of significant difference between the demoralization scores and BMIs of Dominican and African–American women and of immigrant and native-born living in the same health areas indicates that 'racial' and cultural differences have at most little bearing.

The women in the three worst quintiles may be forced to spend unusual amounts of time at home or in the homes of friend and relatives because of the neighborhood conditions. The typical activity scenario becomes one of watching television or video movies and eating, either alone or with family and friends, a prescription for overweight/obesity.

Neighborhood conditions such as characterize the three worst quintiles have often been associated with substance abuse. At the health area level, such indicators of substance abuse as cirrhosis and drug death incidences form part of the picture. The women in the study group, however, do not use illegal drugs, nor do they use large quantities of alcohol. Here is where culture may play a role in risk behavior.

The women in the study group may share an important cultural influence on their behavior, although some are Dominican and others African–American: Christian backgrounds. Their upbringing included implicit or explicit tenets with respect to use of drugs and alcohol, especially by women. The approved ways for women to deal with chronic stress in traditional Christian cultures are limited to eating, talking, arts/crafts, and entertainment such as reading and television. These women share a culture that allows comfort foods.

Eating fatty, sugary foods has long been known as a way of coping with stress. In recent years, a large literature has arisen with the discovery of leptin, the so-called fat hormone. Leptin and the adrenal stress hormones relate to each other in complementary ways. For example: leptin and cortisol show complementary circadian cycles with leptin peaking at night and cortisol during the day (Houseknecht, Baile, Matteri, & Spurlock, 1998). People who do not sleep well because of stress metabolize food differently from those with normal sleep patterns and channel the calories into central abdominal fat deposition (Spiegel, Leproult, & Van Cauter, 1999). Thus, stress, eating, sleep debt, leptin levels, adrenal hormone levels, weight, and central abdominal fat deposition have been linked.

Our results have implications for the debate on the cause of inequalities in health status among people of different socioeconomic status (SES). On one hand, Wilkinson (1996) and Kawachi, Kennedy, Lochner, and Prothrow-Stith (1997) argue that inequality in SES per se fuels this health inequality and that inequality alone imposes stress. On the other hand, Link and Phelan (1999) conclude from their studies that actual deprivations occur due to socioeconomic inequalities. Our results show that the inequalities in the health outcomes (depressive symptoms and overweight/obesity) of the women living in the different quintiles are related to interactions between household economics and neighborhood conditions and are partially based on actual deprivations and insecurities.

Conclusion

We have taken a preliminary look at the effects of chronic community level social and economic stressors on individual emotional status of a highly functional population of poor mothers as measured by a standard instrument. The graph of quintile averages of the index of chronic community stress plotted against the average demoralization scores of the women in the quintiles of chronic stress yielded an inverted 'U' curve with the maximal average demoralization in the middle quintile.

We offer two possible explanations for this curve, which are not mutually exclusive: (1) that a particular level of community chronic stress at or about the level of the middle quintile boosts a signal to the individual or her social network to take action which shields her from community stress, and (2) that very good and very bad community conditions lead to two different stable, safe psychosocial configurations with a distressing and dangerous middle area, for this socially connected cohort of mothers who trust authority enough to enlist in a research study. We speculate that, in either case, this curve depends on the breaking of the weak ties, in Granovetter's (1973) sense, between disjoint social networks and withdrawal from community activity into the homes of members of the social network when community conditions deteriorate. A vicious circle then would ensue, whereby a higher and higher proportion of the civic-minded residents are chased out of the public arena by sheer fatigue, futility, disgust, and fear.

Household economics also influenced demoralization scores. Household economics itself is partly determined by housing costs (rent) which, in turn, are determined by community conditions. Thus, community conditions affected study recruits both directly and indirectly. Women who had experienced a serious deprivation such as recently not being able to pay for food or for housing had much worse demoralization scores than those who did not report such deprivations. Household economics may be one reason for the inverted 'U' shape: in bad neighborhoods, the rents are low and the households have fewer deprivations.

Community conditions determined the pattern of BMI. Where community conditions were bad, the women were decidedly heavier than the women in good neighborhoods. We do not know whether this effect was due to need for 'comfort foods' to cope with the stress or that behavioral pattern of watching television and snacking so common to people staying in the home.

Community conditions and household economics can explain the patterns of health outcomes observed among these women. 'Race', ethnicity, immigrant status, and cultural differences did not explain these patterns.

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Appendix A

The essential driving factor in the analysis is the relative strength of 'weak' and 'strong' social ties within the community. Weak ties, in Granovetter's (1973) terminology, are those which do not disjointly partition a community. Meeting and talking with someone regularly in a park might well be a weak tie, while age cohort, ethnicity, and family relationship would be strong ties.

We can envision the culture of a geographically focused community in terms of a language, in the largest sense, combining behavioral and spoken, and other means of communication between individuals, and between an individual and his or her embedding social structures (Wallace & Wallace, 1998, 1999; Wallace & Fullilove, 1999). Languages are characterized by an information-theoretic 'source uncertainty' which quantifies their efficiency in delivering a message. Languages with high source uncertainty can say much with little, according to theory (e.g. Ash, 1990).

Formally we can express the source uncertainty as follows:

Suppose we can identify a vocabulary of symbols in the language. We ask the number of meaningful statements, $N(n)$ of length n symbols. For regular or 'ergodic' information sources, the source uncertainty of the language is given by the limiting relation

$$H = \lim_{n \to \infty} \frac{\log N(n)}{n}. \tag{A.1}$$

Thus statements in the language can be divided into two sets, a relatively small number of high probability which are consonant with the grammar and syntax of the language, and hence 'meaningful', and a very large number which are not consonant, and are of vanishingly small probability. See Ash (1990), Cover and Thomas (1991), or Khinchine (1957) for details.

Expressing source uncertainty in this form allows identification of a 'homology' with the 'free energy density' of a physical system (Wallace & Wallace, 1998, 1999, 2000; Wallace & Fullilove, 1999; Wallace, 2000; Rojdestvenski & Cottam, 2000) which permits importation of techniques from thermodynamics and statistical mechanics into information theory. Rather than replicate those arguments here, we refer the reader to the references for details.

The essential point is that we can 'parametize' the source uncertainty characteristic of a geographically focused community in terms of an *inverse* index of its strength of weak ties, which we will call K. If P is, for example, the 'ensemble' average probability of weak ties across the community, then we take $K \equiv 1/P$, and write $H = H(K) = \lim_{n \to \infty} \log [N(n, K)]/n$.

Thus, we assume that K is *monotonic in our index of chronic community stress*, that is, K increases uniformly with increase of the index.

Note that, for simplicity, we assume the 'strong' ties to be of a single fixed average probability across the community.

Imposing a thermodynamic formalism, we can write an 'equation of state' for an information system dominated by the relative magnitude of strong and weak social ties as the relation

$$S(K) \equiv H(K) - K\, \mathrm{d}H/\mathrm{d}K. \tag{A.2}$$

S is defined as the *disorder* of the system, and the quantity $I = S - H$ is defined as its *instability*. Again, see Wallace and Fullilove (1999) or Wallace (2002) for details.

Wallace and Fullilove (1999) propose that patterns of risk behavior are proportional to the instability I as the average probability of weak ties (or its inverse $K = 1/P$) changes across the community. Here we postulate that, for our study population, which is well embedded in community, not using drugs, not alienated from authority and, in general, strongly connected with family and friends, individual demoralization is proportional to the community instability index I.

Let the function $I(K)$ follow the functional form of the SNR of a stochastic resonance:

$$I(K) = \frac{1}{K^2}[1 + \alpha \exp(1/(2K))]^{-1}. \tag{A.3}$$

Then, from above, $I(K) = -K\, \mathrm{d}H/\mathrm{d}K$ and we can write

$$\begin{aligned} H(K) &= \int -\frac{I(K)}{K}\, \mathrm{d}K \\ &= \frac{1}{2K^2} - \frac{2}{K}\log[1 + \alpha \exp(1/2K)] \\ &\quad - 4\mathtt{Polylog}[2, -\alpha \exp(1/2K)], \end{aligned} \tag{A.4}$$

where we have set the constant of integration to zero. Polylog[x,y] is a standard tabulated function.

An explicit plot shows $H(K)$ is a reverse S-shaped curve, compared to $I(K)$'s inverted 'U'. The richness of trans-community 'language' declines monotonically with increasing K, the inverse of the average probability of weak ties within the community. This is also a way of saying that the capacity of the community as a communication channel declines with increasing K, since elementary information theory arguments (e.g. Ash, 1990) show $H(K) \leqslant C$ where C is the channel capacity.

Note that the decrease of calculated $H(K)$ is most rapid across the 'hump' of the $I(K)$ plot. If the inverse average probability of weak ties across the community, $K = 1/P$, is monotonically determined by the community chronic stress index, this suggests that the functionality of the Upper Manhattan study zone as a social communication channel decreases very sharply indeed with increasing community stress.

We have a paradoxical result applicable to any reverse S-shaped curve, in that 'instability' will be greatest at intermediate points of stress: the 'falling off a cliff' effect.

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